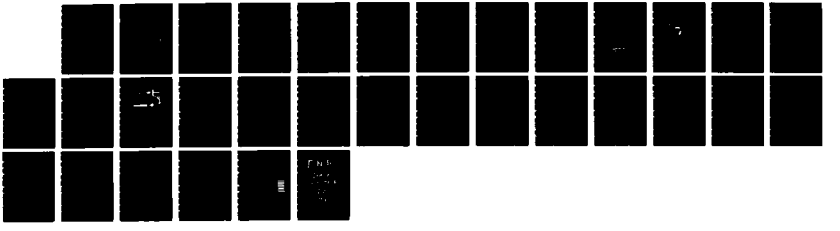
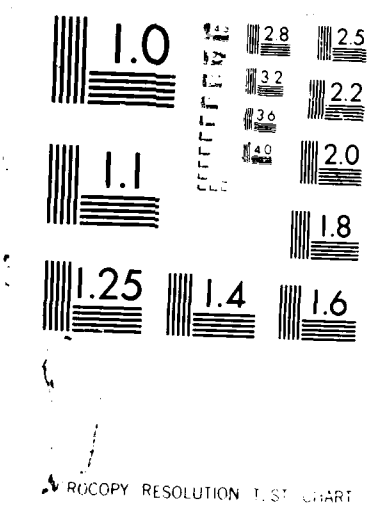
AD-A185 834 KINEMATIC ANALYSIS OF THE M231 FIRING PORT WEAPON(U) 1/1
ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD
T L BROSSEAU ET AL. JUN 87 BRL-MR-3599

UNCLASSIFIED F/G 19/6 NL





AD

(12)

MEMORANDUM REPORT BRL-MR-3599

KINEMATIC ANALYSIS OF THE M231 FIRING PORT WEAPON

T. L. BROSSEAU
R. P. KASTE

JUNE 1987

US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

Destroy this report when it is no longer needed.
Do not return it to the originator.

Additional copies of this report may be obtained from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161.

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

The use of trade names or manufacturers' names in this report does not constitute indorsement of any commercial product.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188
Exp. Date Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: USA Ballistic Research Lab; 6b. OFFICE SYMBOL (If applicable): SLCBR-IB	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code): Aberdeen Proving Ground, MD 21005-5066	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO
P612618	AH80		

11. TITLE (Include Security Classification)

KINEMATIC ANALYSIS OF THE M231 FIRING PORT WEAPON

12. PERSONAL AUTHOR(S)
T.L. Brosseau, R.P. Kaste

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
FINAL	FROM Oct 85 TO May 87		

16 SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	M231
19	06		Kinematic Study

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The firing characteristics of a new M231 Firing Port Weapon were checked while firing M196 ammunition loaded with ball and IMR type propellants. Measurements of muzzle velocity and rate of fire were made during these tests. The average muzzle velocity for the M196 ammunition loaded with ball and IMR type propellants is about 914 m/s. The average rate of fire for the M196 ammunition loaded with ball propellant is about 1255 rds/min which is about 50 rds/min higher than the average rate of fire for the M196 ammunition with IMR type propellant.

A complete kinematic study was also made on a new lubricated weapon while firing M196 ammunition loaded with ball and IMR type propellants. Displacement versus time of the bolt carrier and the striker were measured using electro-optical displacement followers, Optrons, during firing of the test rounds. Pressure versus time in the bolt cavity was measured using a Kistler 601H Pressure Gage during firing of the test rounds.

(continued on other side)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
Timothy L. Brosseau	(301) 278-6145	SLCBR-IB-W

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

19. (cont.)

A sensitivity study was also made on a new weapon while firing under the following test conditions:

1. The weapon was fired completely dry with no lubrication using M196 ammunition loaded with ball and IMR propellants.

2. The weapon was fired with ammunition and weapon conditioned at 225.8K and 341.5K using M196 ammunition loaded with ball and IMR propellants.

3. The weapon was fired using M193 ammunition from Lot No. LC4-85.

Displacement versus time of the bolt carrier, and pressure versus time in the bolt cavity were measured during firing of the test rounds.

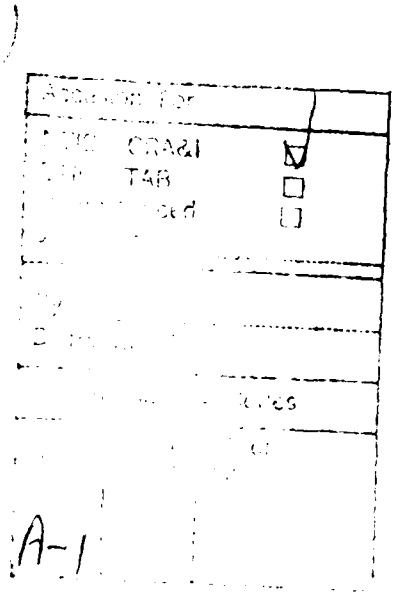


TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS..... 5

LIST OF TABLES..... 7

I. INTRODUCTION..... 9

II. DESCRIPTION OF M231 FIRING PORT WEAPON..... 9

III. FUNCTIONING OF M231 FIRING PORT WEAPON..... 10

IV. FIRING CHARACTERISTICS OF M231 FIRING PORT WEAPON..... 11

A. Measurements..... 11

1. Muzzle Velocity..... 11

2. Rate of Fire..... 11

B. Test Setup and Procedure..... 11

C. Results..... 11

D. Discussion..... 11

1. Muzzle Velocity..... 11

2. Rate of Fire..... 14

V. KINEMATIC STUDY OF M231 FIRING PORT WEAPON..... 14

A. Measurements..... 14

1. Displacement versus Time..... 14

2. Pressure versus Time..... 14

3. Recoil Time..... 14

4. Cycle Time..... 14

B. Test Setup and Procedure..... 14

C. Results..... 14

D. Discussion..... 19

1. Bolt Carrier Displacement..... 19

2. Magnified Initial Bolt Carrier Displacement and Magnified Initial Striker Displacement..... 19

TABLE OF CONTENTS (continued)

Page

3. Magnified Initial Bolt Carrier Displacement and Bolt Cavity Pressure..... 19

VI. SENSITIVITY STUDY OF M231 FIRING PORT WEAPON..... 19

A. Measurements..... 20

B. Test Setup and Procedure..... 20

C. Results..... 20

D. Discussion..... 20

1. Unlubricated Weapon..... 20

2. Weapon and Ammunition Conditioned at 225.8K and 341.5K..... 20

3. Weapon Firing M193 Ammunition..... 26

DISTRIBUTION LIST..... 27

LIST OF ILLUSTRATIONS

Figure		Page
1	M231 Firing Port Weapon	9
2	Functioning Components of M231 Firing Port Weapon	10
3	Projectile Velocity Versus Downrange Distance from the Muzzle of M231 Firing Port Weapon	12
4	Rate of Fire Versus Round Number in Thirty-Round Burst from M231 Firing Port Weapon	13
5	M231 Firing Port Weapon in Rigid Mount	15
6	Displacement Versus Time of Bolt Carrier in M231 Firing Port Weapon	16
7	Magnified Initial Displacement Versus Time of Bolt Carrier and Striker in M231 Firing Port Weapon	17
8	Magnified Initial Bolt Carrier Displacement and Bolt Cavity Pressure Versus Time in M231 Firing Port Weapon	18
9	Maximum Bolt Cavity Pressure Versus Conditioning Temperature in M231 Firing Port Weapon	23
10	Maximum Bolt Cavity Pressure Versus Recoil Time in M231 Firing Port Weapon	24
11	Maximum Bolt Cavity Pressure Versus Cycle Time in M231 Firing Port Weapon	25

LIST OF TABLES

Table		Page
1	Results of Firing Characteristics Tests	11
2	Results of Kinematic Tests	15
3	Results of Kinematic Tests	15
4	Results of Sensitivity Tests	21
5	Results of Sensitivity Tests	22

I. INTRODUCTION

The original Firing Port Weapon was designed at the Ballistic Research Laboratory (BRL) at the request of the Small Arms Systems Agency. The first weapons that were fired in DT I tests at the Test and Evaluation Command (TECOM) were fabricated at BRL according to this original design. However, since these DT I tests several design changes have been made to improve the reliability of the weapon and to meet new requirements by the user. The present weapon that has successfully completed tests at TECOM is designated the M231 Firing Port Weapon, and all of the design changes made to this weapon have been a joint effort between BRL and the Small Caliber Weapons System Laboratory. While the design changes have improved the reliability of the weapon they have also changed the firing and the operating characteristics of the original weapon. Therefore, to check the firing characteristics of the present M231 Firing Port Weapon, firing tests were conducted at BRL on a new weapon. To redefine the operating characteristics of the present M231 Firing Port Weapon a complete kinematic study was also performed on a new instrumented weapon. A kinematic study was also done on the instrumented new weapon under several different changes in ammunition and operating environment to determine the sensitivity of the weapon to these changes.

II. DESCRIPTION OF M231 FIRING PORT WEAPON

The M231 is a 5.56 mm fully automatic weapon that uses a heavy barrel and fires from the open bolt position, to prevent cookoffs, to allow a sustained firing rate of 60 rds/min. The weapon is fired from a ball and socket mount inside the new Infantry Fighting Vehicle to provide suppressive fire to the sides and rear of the vehicle. The weapon is shown in Figure 1.

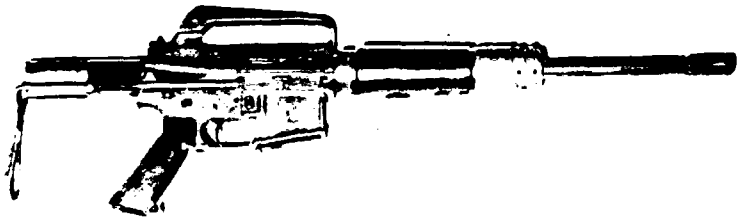


Figure 1. M231 Firing Port Weapon

III. FUNCTIONING OF M231 FIRING PORT WEAPON

The functioning components of the M231 Firing Port Weapon are shown in Figure 2.

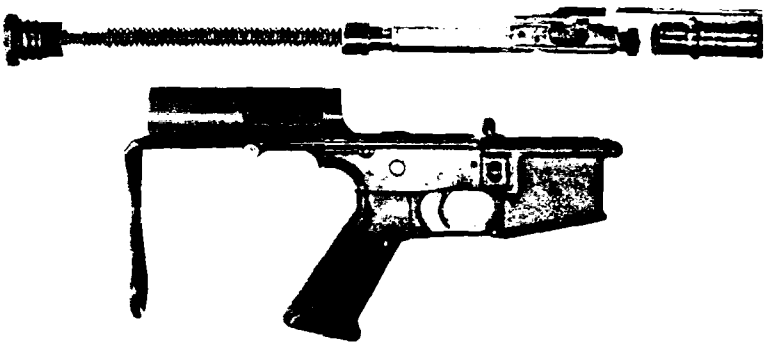


Figure 2. Functioning Components of M231 Firing Port Weapon

Since the weapon fires from the open bolt position the bolt carrier must first be seared to the rear before firing can begin. When the trigger is pulled the sear is rotated downward out of the sear notch, the bolt carrier starts forward and the bolt lug strips the first round from the magazine. When the bolt carrier is fully forward and the bolt is locked, the striker contacts the end of the firing pin and the first round is fired. After the projectile passes the gas port hole in the barrel, propellant gas passes out through the regulating hole in the gas seal, and down the gas tube. The gas enters the bolt cavity and pushes forward on the bolt and rearward on the bolt carrier. As the bolt carrier moves rearward it rotates the bolt by means of a cam and pin which unlocks the bolt from the barrel extension. When the bolt carrier has moved rearward a short distance, two vent holes in the bolt carrier are uncovered and the remaining gas in the gas tube is released to the atmosphere. A spring loaded extractor pulls the fired cartridge case from the chamber as the bolt moves rearward after unlocking. A spring loaded plunger in the face of the bolt ejects the cartridge case after extraction. The bolt carrier continues rearward until it contacts the washer and Buna-N rubber buffer, which are held by the drive spring retainer plug. The bolt carrier then starts forward, unless caught by the sear or the bolt latch on the last round, and the bolt lug strips the next round from the magazine and the cycle repeats.

IV. FIRING CHARACTERISTICS OF M231 FIRING PORT WEAPON

To check the firing characteristics of the present M231 Firing Port Weapon, firing tests were conducted with a new lubricated weapon while firing standard M196 ammunition. Since standard M196 ammunition is loaded with either IMR or ball propellant a lot with each type of propellant was used.

A. Measurements

1. Muzzle Velocity. The projectile velocity at the muzzle of the weapon was measured using five Lumiline Screens placed downrange. As the projectile passed through the screens, electronic counters were activated which recorded the time of flight between screens. The average projectile velocity midway between each combination of screens was calculated and then extrapolated back to the muzzle.

2. Rate of Fire. The rate of fire was measured from the round-to-round time intervals, as sensed by a Lumiline Screen and recorded by an electronic counter and a printer.

B. Test Setup and Procedure

The weapon was constrained in a ball and socket mount. Thirty-round burst tests were fired using M196 ammunition from Lot No. TW18204 (IMR propellant), and Lot No. LC80-H0106012 (ball propellant). The firing tests were conducted with a lubricated weapon. In all tests LSA was used as a lubricant which was liberally applied before each firing test.

C. Results

The results of the test firings are summarized in Table 1, and sample records are shown in Figures 3 and 4.

TABLE 1. RESULTS OF FIRING CHARACTERISTICS TESTS

TEST CONDITION	Firing Interval (ms) Ave	σ	Rate of Fire (rds/min) Ave	σ	Muzzle Velocity (m/s)	σ
AMMO LOT NO. TW18204	49.8	1.4	1205.	30.	913.0	12.0
AMMO LOT NO. LC80-H0106012	47.8	1.6	1255.	33.	914.5	10.5

D. Discussion

1. Muzzle Velocity The average measured muzzle velocity of the M231 Firing Port Weapon is higher than the average measured muzzle velocity of the original Firing Port Weapon tested in DT I. The reason for this is that the barrel in the present M231 is longer than the barrel in the original Firing Port Weapon tested in DT I.

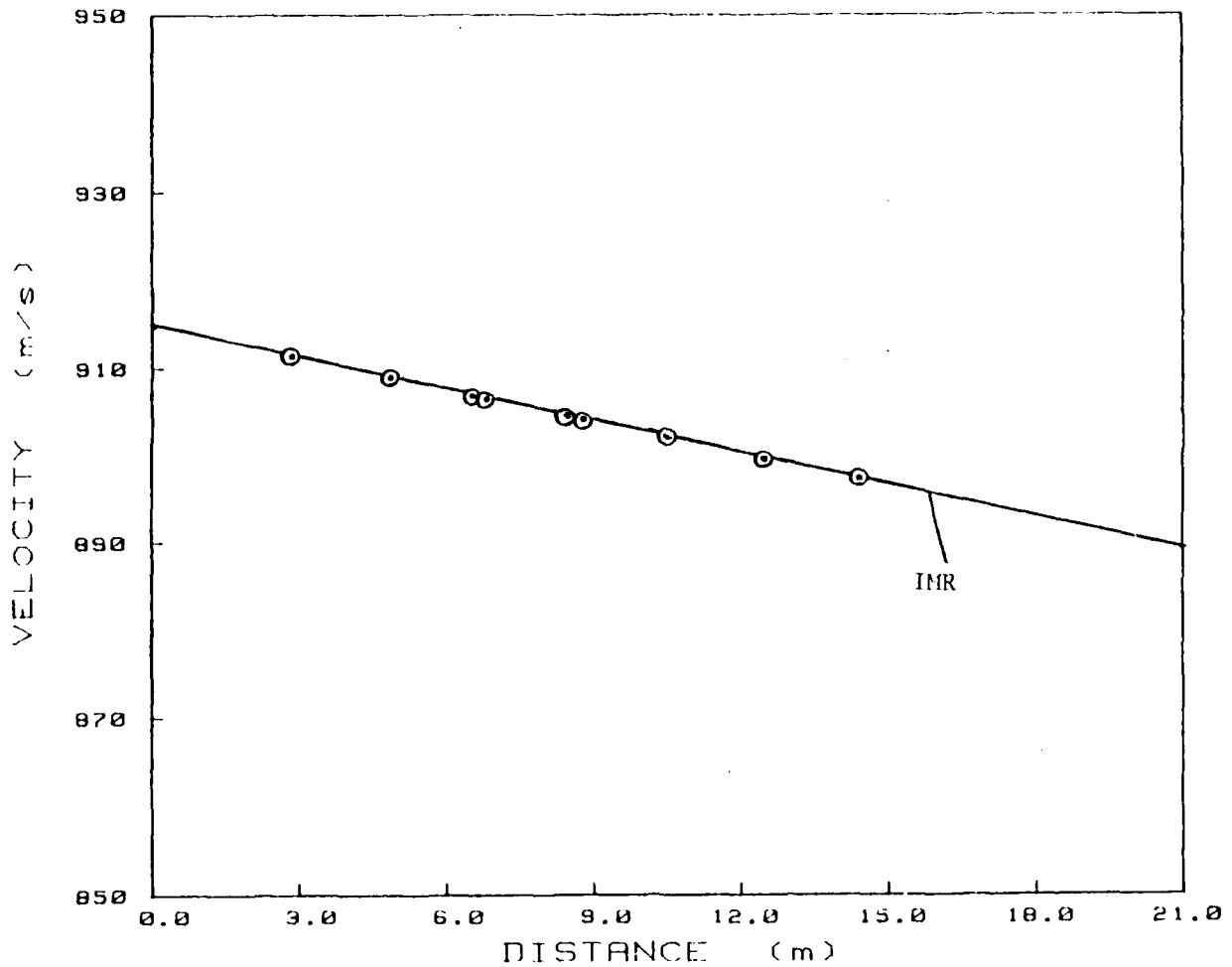


Figure 3. Projectile Velocity Versus Downrange Distance from the Muzzle of M231 Firing Port Weapon

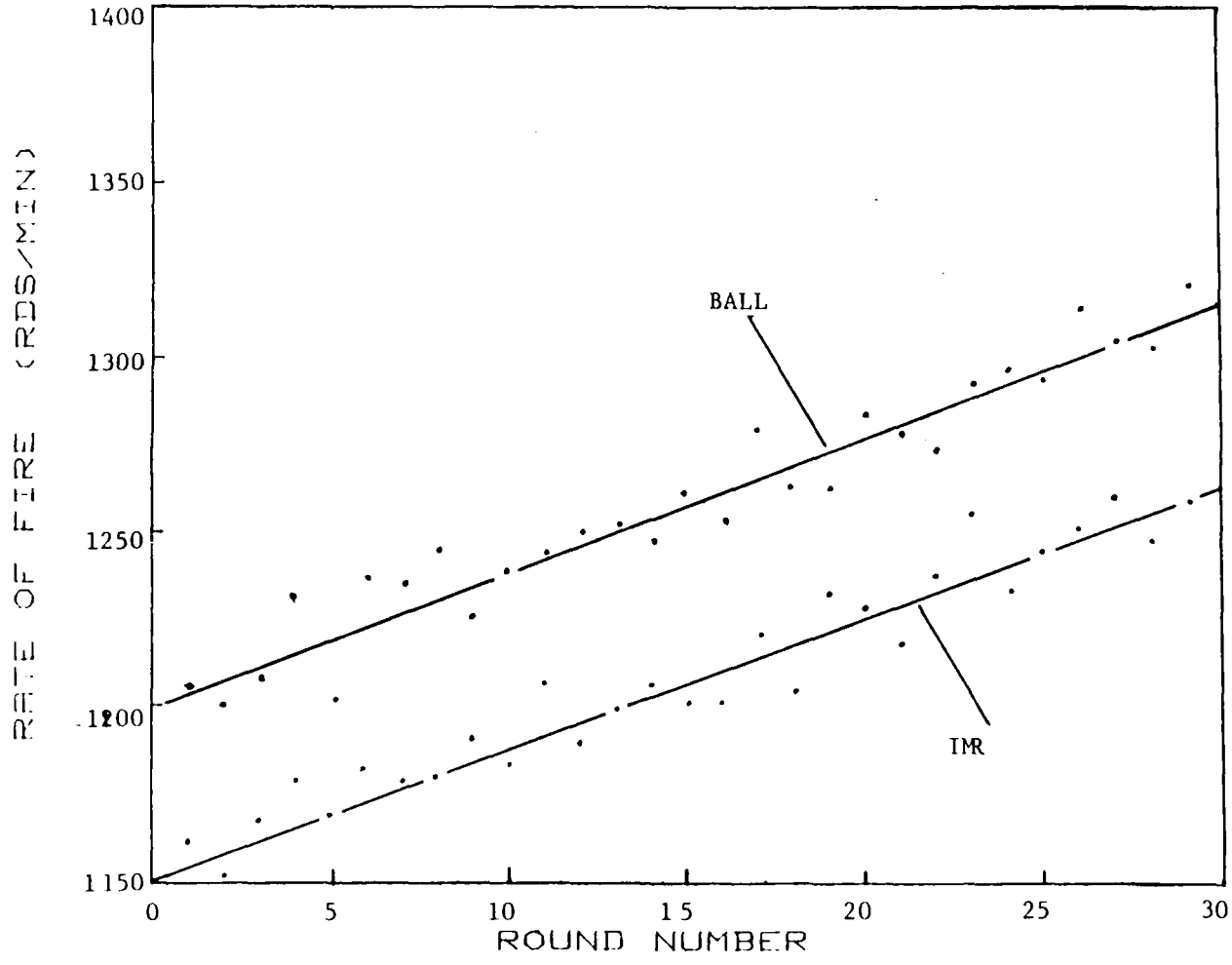


Figure 4. Rate of Fire Versus Round Number in Thirty-Round Burst from M231 Firing Port Weapon

2. Rate of Fire. The results show that the average rate of fire for the weapon firing ammunition from Lot No. TW18204 is about 50 rds/min less than the average rate of fire when firing ammunition from Lot No. LC80-H0106012. The results also show that the rate of fire increases slightly during the firing of a thirty round burst. The amount of increase is about 3.5 rds/min for each round fired in a continuous burst.

V. KINEMATIC STUDY OF M231 FIRING PORT WEAPON

To redefine the operating characteristics of the present M231 Firing Port Weapon, a complete kinematic study was made on a new lubricated weapon while firing standard M196 ammunition with IMR propellant and ball propellant.

A. Measurements

1. Displacement versus Time. The overall displacement of the bolt carrier was measured using an electro-optical displacement follower, Optron, during firing of the test rounds. The magnified initial displacements of the bolt carrier and the striker were also measured with Optrons during firing of the test rounds.

2. Pressure versus Time. The pressure in the bolt cavity was measured using a Kistler 601H Pressure Gage during firing of the test rounds.

3. Recoil Time. The time required for the bolt carrier to move from battery to its maximum rearward position was measured from the overall displacement versus time records.

4. Cycle Time. The time required for the bolt carrier to move rearward from battery and return to battery was measured from the overall displacement versus time records.

B. Test Setup and Procedure

The weapon was constrained in a rigid mount by clamping the weapon tightly at the barrel collar, as shown in Figure 5. Single-round tests were fired when measuring bolt cavity pressure with the instrumented bolt carrier. Single round tests were also fired when measuring displacement of the bolt carrier with the original new bolt carrier. In all of the firing tests M196 ammunition from Lot No. TW18204 and Lot No. LC80-H0106012 was fired from a full thirty-round magazine. A dummy round was inserted in the magazine to stop cycling of the weapon after the first round. All of the firing tests were conducted with a lubricated weapon and chamber. In all tests LSA was used as a lubricant and applied before each firing test.

The pressure in the bolt cavity and the displacement of the bolt carrier were recorded on a four-channel waveform recorder, Biomation, and plots were obtained from an oscilloscope and a Hewlett Packard plotter.

C. Results

The results of the test firings are summarized in Tables 2 and 3. Sample records are shown in Figures 6 thru 8.

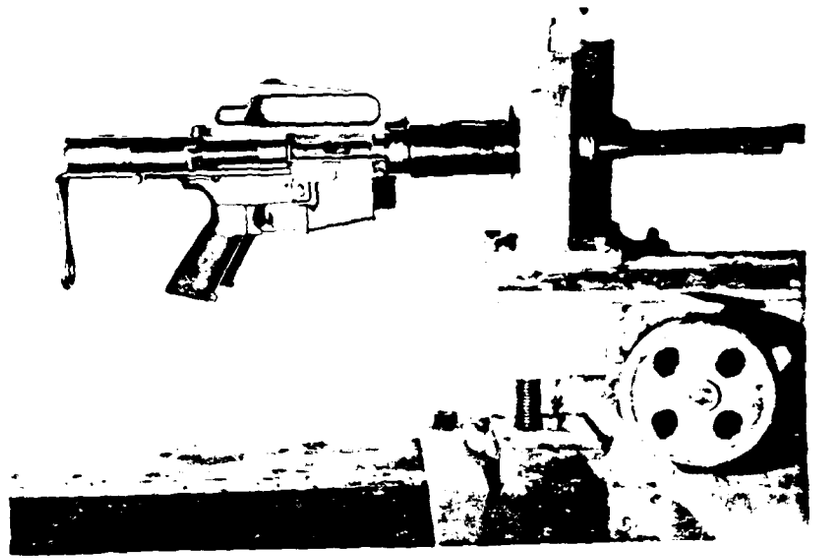


Figure 5. M231 Firing Port Weapon in Rigid Mount

TABLE 2. RESULTS OF KINEMATIC TESTS

Test Conditon	Maximum Bolt Cavity Pressure, (MPa) Ave	σ	Velocity of Bolt Carrier at Primer Contact, (m/s) Ave	σ	Displacement of Bolt Carrier at Start of Pressure Rise, (mm) Ave	σ
Ammo Lot No. TW18204	17.31	.06	4.36	.03	1.14	.02
Ammo Lot No. LC80-H0106012	18.48	.05	4.33	.03	1.13	.03

TABLE 3. RESULTS OF KINEMATIC TESTS

Test Condition	Maximum Bolt Carrier Displacement, (mm)	Recoil Time (ms) Ave	σ	Cycle Time (ms) Ave	σ
Ammo Lot No. TW18204	Buffer Contact	25.0	.4	54.0	.8
Ammo Lot No. LC80-H0106012	Buffer Contact	22.0	.3	50.0	.7

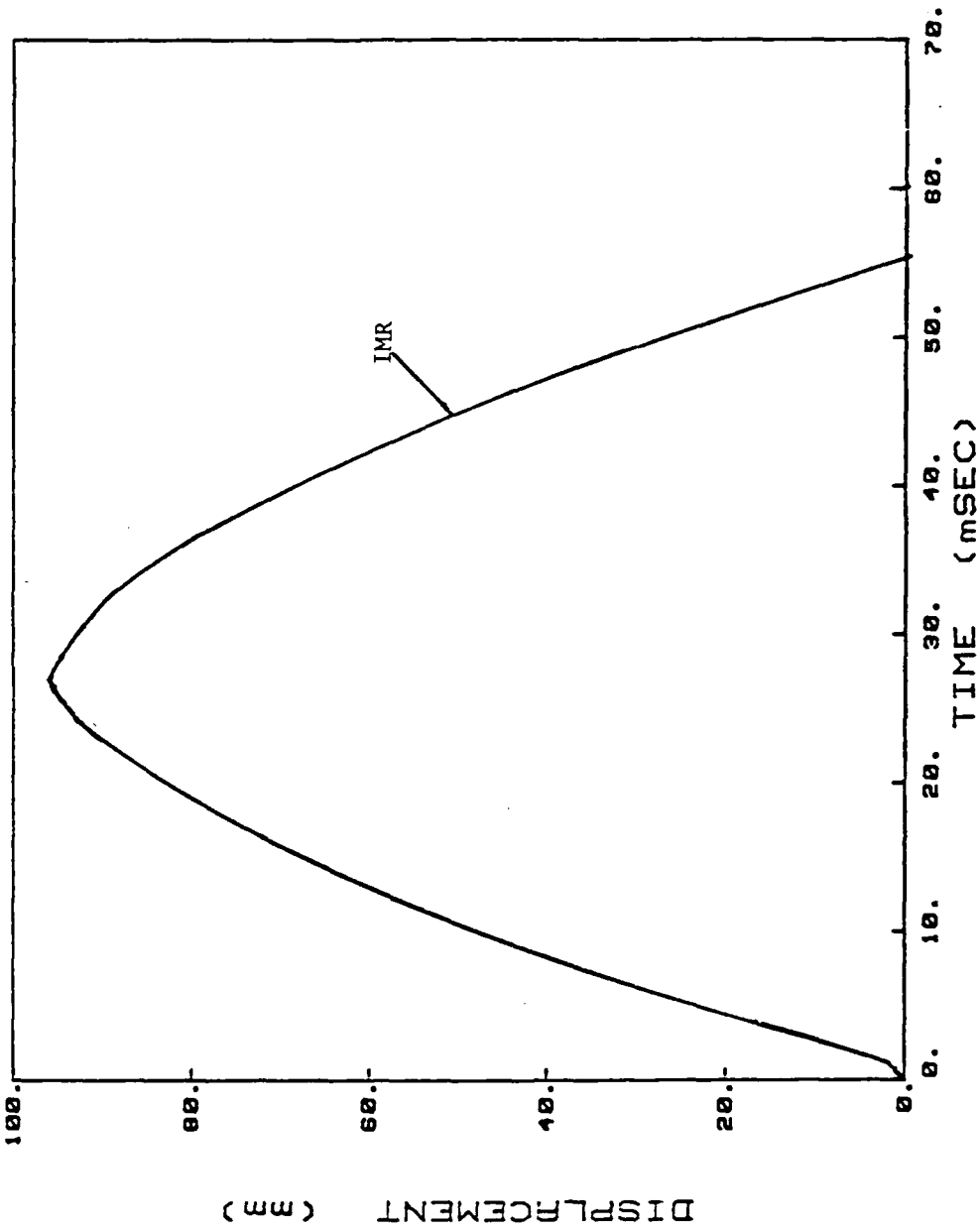


Figure 6. Displacement Versus Time of Bolt Carrier in M231 Firing Port Weapon

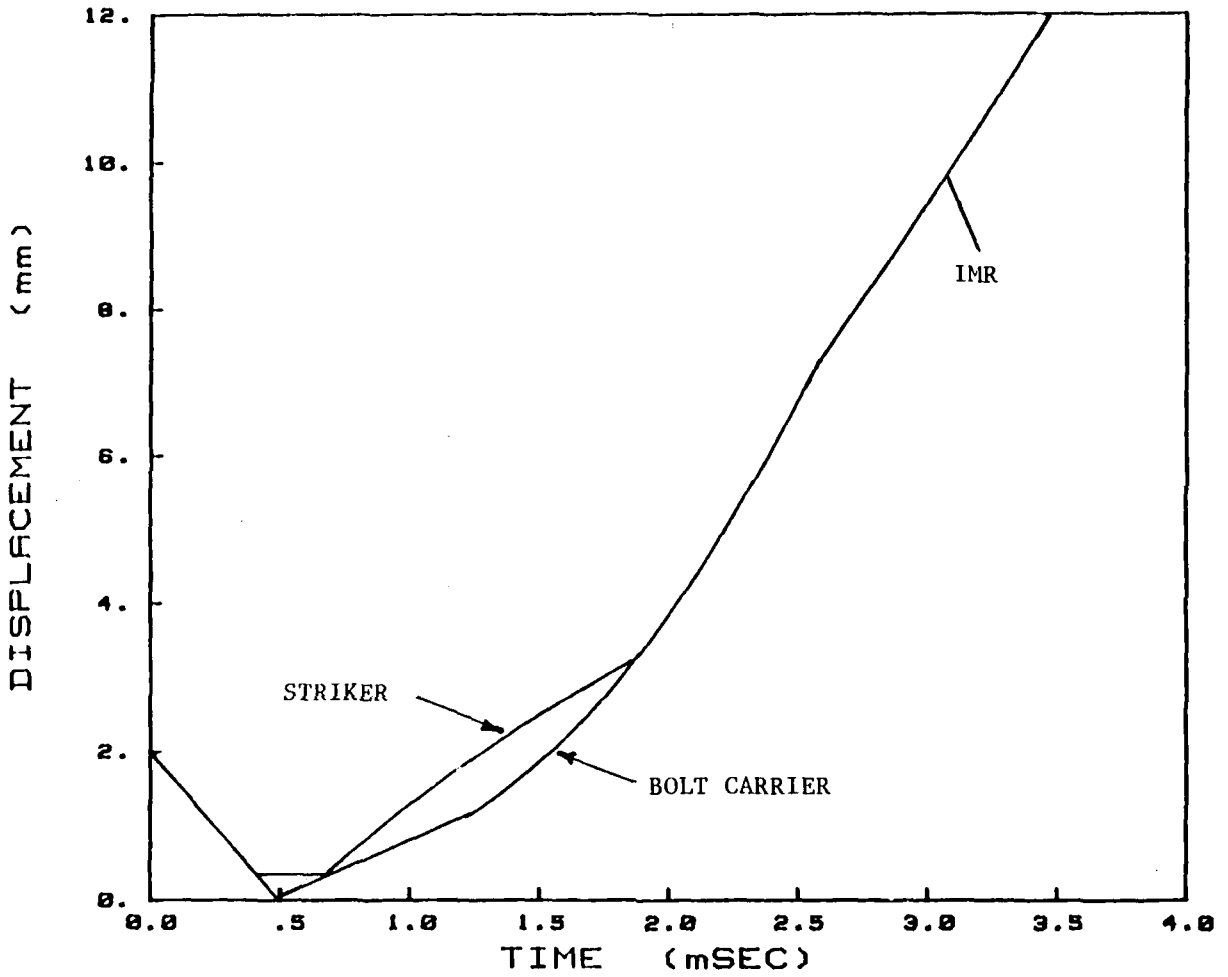


Figure 7. Magnified Initial Displacement Versus Time of Bolt Carrier and Striker in M231 Firing Port Weapon

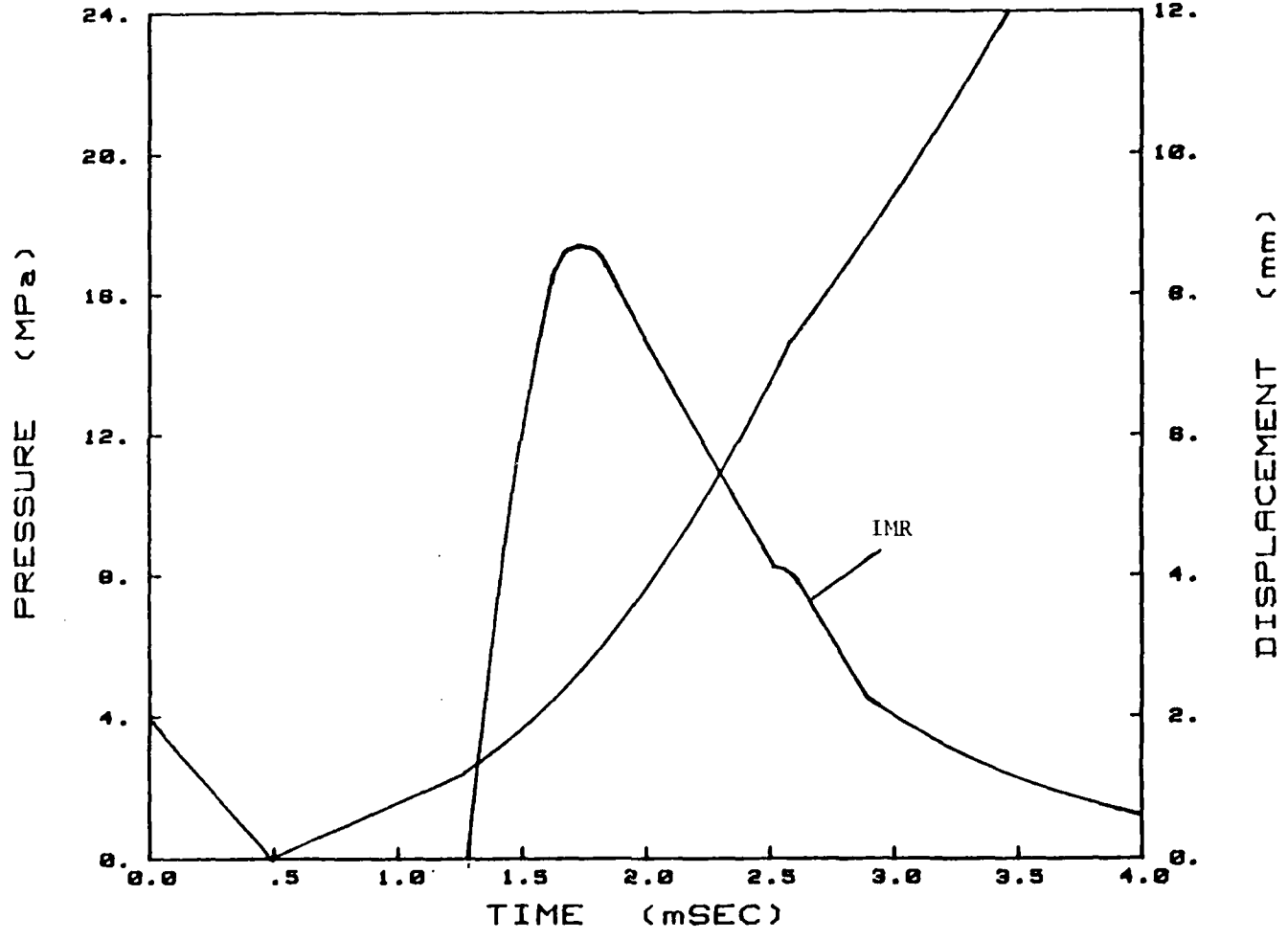


Figure 8. Magnified Initial Bolt Carrier Displacement and Bolt Cavity Pressure Versus Time in M231 Firing Port Weapon

D. Discussion

1. Bolt Carrier Displacement. Figure 6 shows a typical bolt carrier displacement versus time record for a new lubricated weapon firing M196 ammunition with IMR propellant. The bolt carrier displacement versus time record for the weapon firing M196 ammunition with ball propellant under similar conditions is essentially the same as with the IMR propellant except that the cycle time is 4 ms shorter. The results for both types of propellant show that the bolt carrier will sear up, latch up after the last round in the magazine has been fired, and also contact the buffer.

2. Magnified Initial Bolt Carrier Displacement and Magnified Initial Striker Displacement. Figure 7 shows a typical magnified initial bolt carrier displacement versus time record, and a simultaneously measured magnified initial striker displacement versus time record. These records show that the bolt carrier and the striker are moving together at a uniform velocity at primer contact. The velocity of the striker at primer contact can therefore be easily measured from the magnified initial bolt carrier displacement versus time record. The records also show that after primer contact the striker separates from the bolt carrier until after 3.2 mm of rearward travel when they come together again.

3. Magnified Initial Bolt Carrier Displacement and Bolt Cavity Pressure. Figure 8 shows a typical magnified initial bolt carrier displacement versus time record and a simultaneously measured bolt cavity pressure versus time record. The records show that the bolt carrier has already moved rearward 1.14 mm, by bouncing off the barrel extension, before the pressure in the bolt cavity starts to rise. The magnified initial bolt carrier displacement versus time record shows that the bolt carrier accelerates very rapidly after the start of pressure rise in the bolt cavity until it picks up the bolt after unlocking. The bolt carrier then decelerates rapidly until the oscillations between the bolt carrier and the bolt are damped out, and then accelerates again until the pressure in the bolt cavity returns to zero. Because of these rapid accelerations and decelerations of the bolt carrier in its initial rearward motion, it is very difficult to measure a reliable maximum rearward velocity of the bolt carrier from the magnified initial bolt carrier displacement versus time record. The results show that the maximum bolt cavity pressure is 1.17 MPa lower for the M196 ammunition with IMR propellant than for the M196 ammunition with ball propellant. This lower maximum bolt cavity pressure accounts for the longer cycle time for the M196 ammunition with IMR propellant.

VI. SENSITIVITY STUDY OF M231 FIRING PORT WEAPON

To determine the sensitivity of the present M231 Firing Port Weapon to changes in ammunition and operating environment, kinematic measurements were made while firing a new weapon under the following test conditions.

1. The weapon was fired completely dry with no lubrication using M196 ammunition from Lot No. TW18204 and Lot No. LC80-H0106012.

2. The weapon was fired with ammunition and weapon conditioned at 225.8K and 341.5K using M196 ammunition from Lot No. TW18204 and Lot No. LC80-H0206012.

3. The weapon was fired using M193 ammunition from Lot No. LC4-85.

A. Measurements

The same measurements were made as in the previous kinematic study, except no striker displacement versus time measurements were made.

B. Test Setup and Procedure

The same test setup and procedures were used as in the previous kinematic study. In the test firing at 225.8K LAW was used as a lubricant and applied before each firing test.

C. Results

The measurements were analyzed in the same manner as in the previous kinematic study and the records obtained were similar to those obtained in the previous kinematic study. The results are summarized in Tables 4 and 5 and Figures 9 thru 11.

D. Discussion

1. Unlubricated Weapon. The results show that the bolt carrier of a new unlubricated weapon firing M196 ammunition from Lot No. TW18204 will sear up, latch up after the last round in the magazine has been fired, but will not contact the buffer. However, the bolt carrier of the weapon under the same conditions while firing M196 ammunition from Lot No. LC80-H0106012 will contact the buffer. There is a big difference in the cycle times between the two lots of M196 ammunition fired in an unlubricated weapon because in one lot the bolt carrier rebounds off from the buffer, but in the other lot it does not, and consequently the cycle time is much longer.

The results also show that the lack of lubrication has no effect on the displacement of the bolt carrier at the start of pressure rise in the bolt cavity, or the maximum pressure in the bolt cavity. However, the velocity of the bolt carrier at primer contact is slightly lower because of greater losses due to friction upon closing of the bolt carrier.

2. Weapon and Ammunition Conditioned at 225.8K and 341.5K. The results show that the bolt carrier of a new lubricated weapon will sear up, latch up after the last round in the magazine has been fired, and contact the buffer when weapon and ammunition are conditioned and fired at 225.8K and 341.5K with the two lots of M196 ammunition.

The results also show that the displacement of the bolt carrier at the start of pressure rise in the bolt cavity is less at 225.8K than at ambient conditions, but the same at 341.5K as at ambient condition. With the two lots of M196 ammunition, the maximum pressure in the bolt cavity decreases at 225.8K and increases at 341.5K, over the maximum pressure in the bolt cavity at ambient conditions. The effect of the conditioning temperature on the maximum bolt cavity pressure is shown in Figure 9. The velocity of the bolt carrier at primer contact is lower at 225.8K than at ambient conditions, but the same at 341.8K as at ambient conditions.

TABLE 4. RESULTS OF SENSITIVITY TESTS

Weapon Condition	Test Variable	Maximum Bolt Carrier Displacement (mm)	Recoil Time (ms) Ave	Recoil Time (ms) σ	Cycle Time (ms) Ave	Cycle Time (ms) σ
unlubricated	ammo lot no. TW18204	1.0 short of buffer	29.0	.4	61.0	.7
unlubricated	ammo lot no. LC80-H0106012	buffer contact	26.0	.5	55.0	.8
lubricated 225.8 K	ammo lot no. TW18204	buffer contact	28.0	.5	59.0	.9
lubricated 225.8 K	ammo lot no. LC80-H0206012	buffer contact	26.0	.4	55.0	.8
lubricated 341.5 K	ammo lot no. TW18204	buffer contact	23.0	.5	52.0	.9
lubricated 341.5 K	ammo lot no. LC80-H0106012	buffer contact	21.0	.3	48.0	.7
lubricated	M193 ammo	buffer contact	20.0	.4	47.0	.8

TABLE 5. RESULTS OF SENSITIVITY TESTS

Weapon Condition	Test Variable	Maximum Bolt Cavity Pressure, (MPa) Ave	σ	Velocity of Bolt Carrier at Primer Contact, (m/s) Ave	σ	Displacement of Bolt Carrier at Start of Pressure Rise, (mm) Ave	σ
unlubricated	ammo lot no. TW18204	17.37	.07	4.24	.04	1.11	.04
unlubricated	ammo lot no. LC80-H0106012	18.42	.05	4.22	.03	1.09	.02
lubricated 225.8 K	ammo lot no. TW18204	16.55	.05	3.93	.04	1.04	.03
lubricated 225.8 K	ammo lot no. LC80-H0106012	17.66	.06	3.95	.05	1.06	.04
lubricated 341.5 K	ammo lot no. TW18204	17.93	.07	4.33	.02	1.13	.03
lubricated 341.5 K	ammo lot no. LC80-H0106012	19.03	.06	4.35	.03	1.14	.02
lubricated	M193 ammo	19.65	.08	4.37	.04	1.15	.04

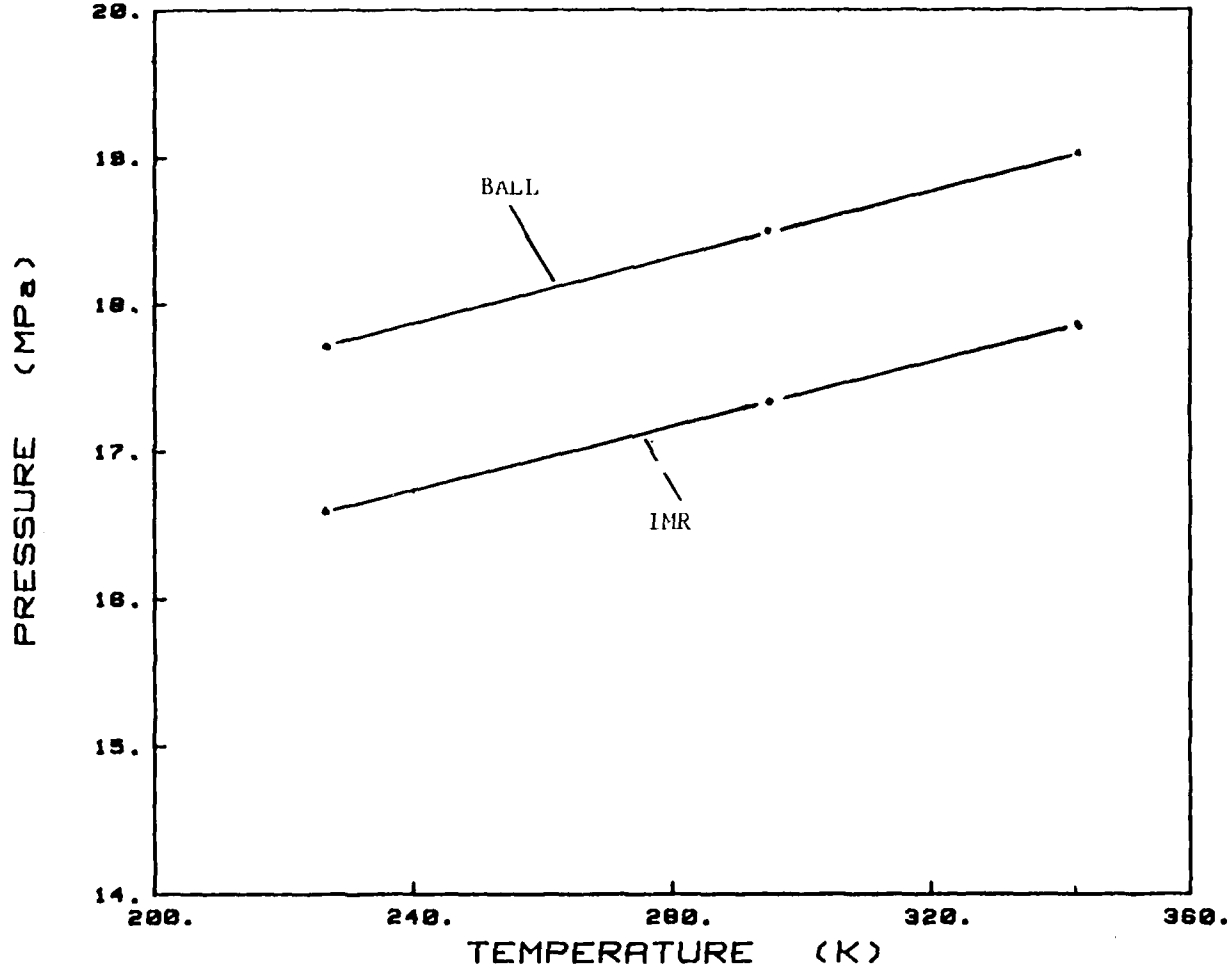


Figure 9. Maximum Bolt Cavity Pressure Versus Conditioning Temperature in M231 Firing Port Weapon

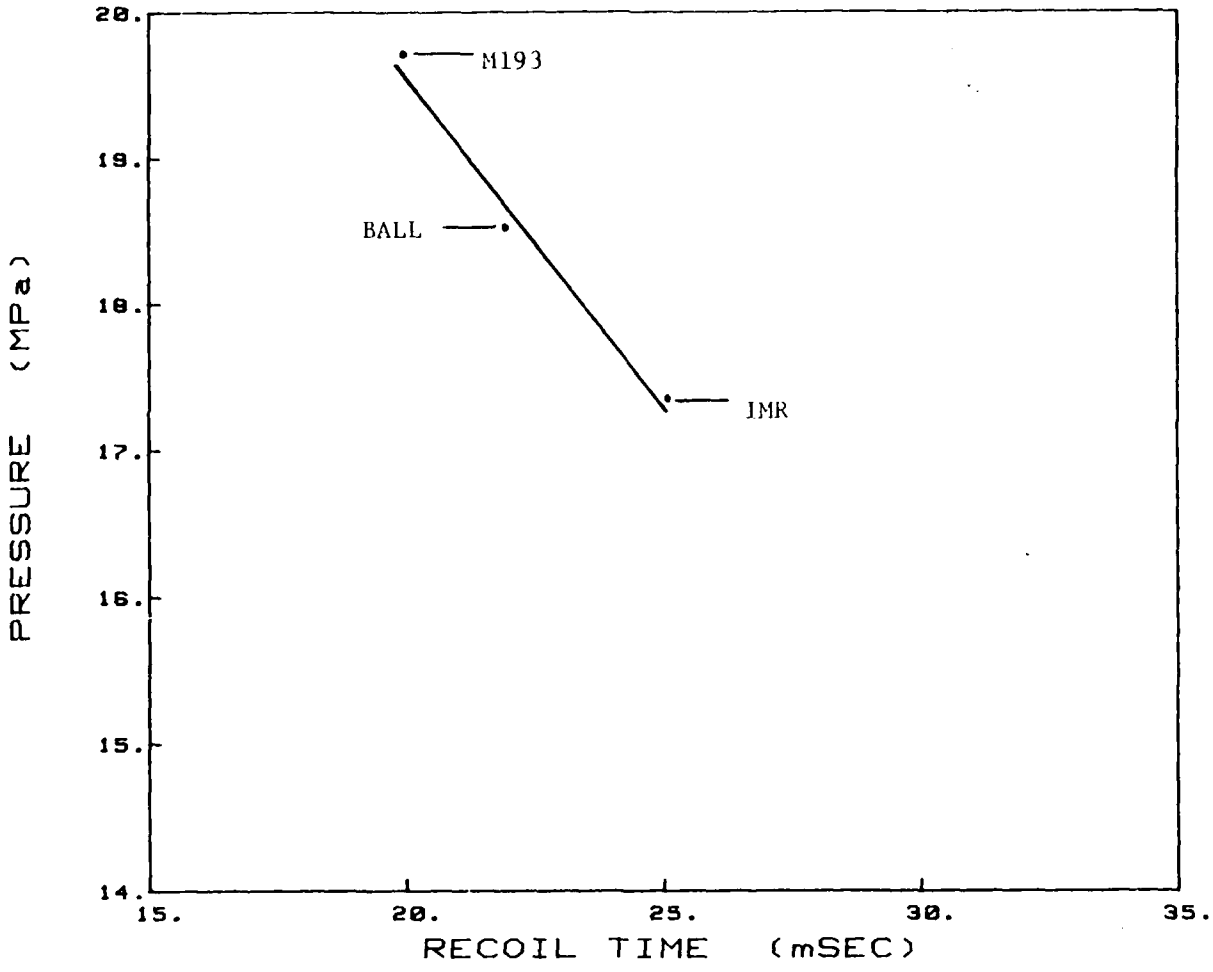


Figure 10. Maximum Bolt Cavity Pressure Versus Recoil Time in M231 Firing Port Weapon

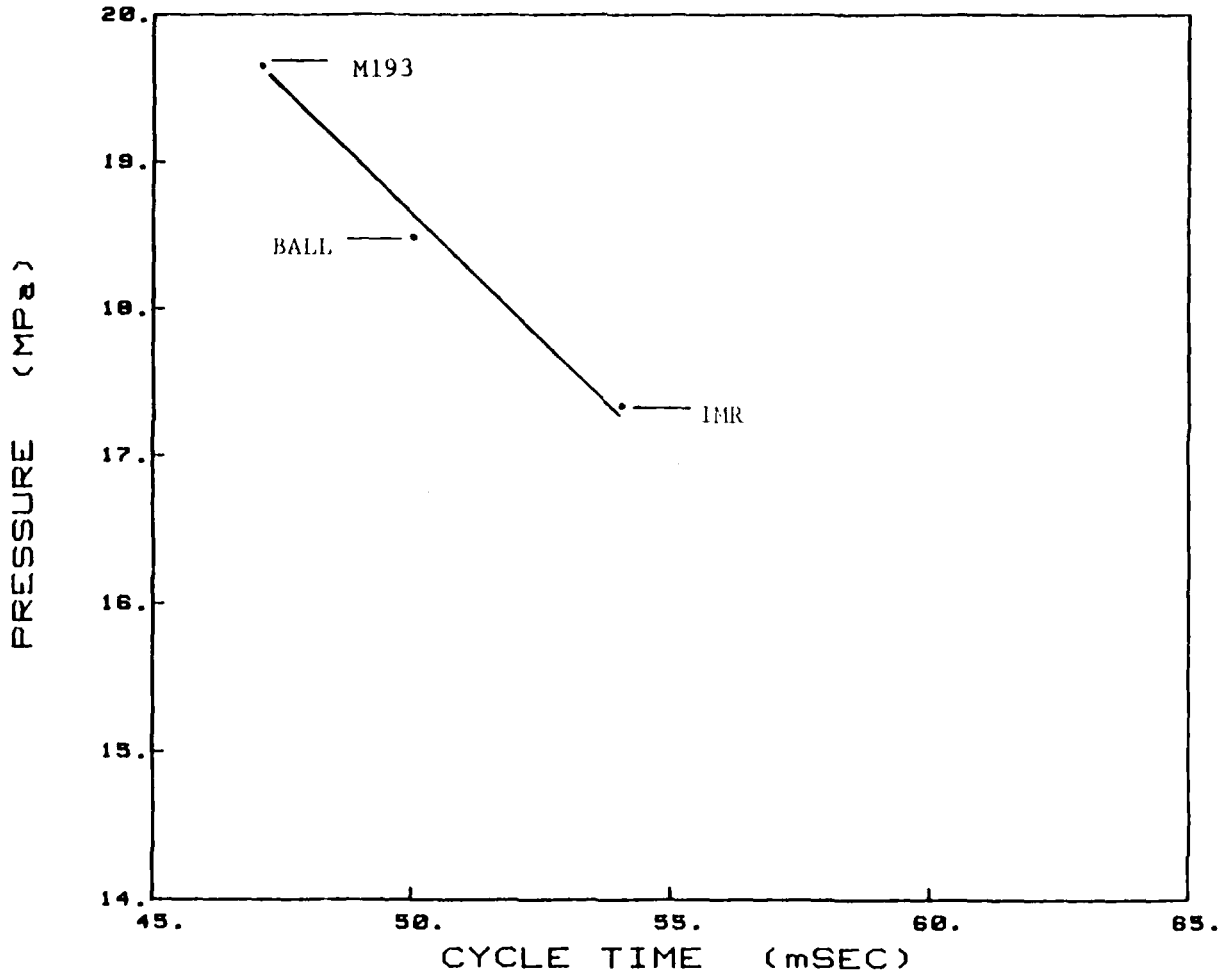


Figure 11. Maximum Bolt Cavity Pressure Versus Cycle Time in M231 Firing Port Weapon

3. Weapon Firing M193 Ammunition The results show that the bolt carrier of a new lubricated weapon firing M193 ammunition will sear up, latch up after the last round in the magazine has been fired, and contact the buffer with a lubricated weapon. The recoil times and cycle times when firing M193 ammunition are lower than those of a corresponding new weapon firing M196 ammunition from either lot.

The results also show that the displacement of the bolt carrier at the start of pressure rise in the bolt cavity, and the velocity of the bolt carrier at primer contact when firing M193 ammunition are the same as those of a corresponding new weapon firing M196 ammunition. However, the maximum pressure in the bolt cavity, when firing M193 ammunition, is higher than that of a corresponding new weapon firing M196 ammunition. The effect of the maximum pressure in the bolt cavity on the recoil time and the cycle time in a new lubricated weapon is shown in Figures 10 and 11. The plots shown in Figures 9 thru 11 also include the results from the previous firings with the two lots of M196 ammunition.

DISTRIBUTION LIST

No. of Copies	Organization
12	Administrator Defense Technical Info Center ATTN: DTIC-DDA Cameron Station Alexandria, VA 22394-6145
1	USDDR&E ATTN: R. Heaston The Pentagon Room 3D1089 Washington, DC 20301
6	Headquarters Department of the Army ATTN: DAMA-CSM DAMA-WSA DAMA-WSZ-A DAMA-WSW DAMA-ART-M DACS-DM, J. Tucker Jr. Washington, DC 20310
3	Commander US Army Materiel Command ATTN: AMCDMD-ST AMCDE-SG AMCDRA-ST 5001 Eisenhower Avenue Alexandria, VA 22333
2	Commander US Army Laboratory Command ATTN: AMSLC-TD 2800 Powder Mill Road Adelphi, MD 20783-1145
1	Commander US Army Laboratory Command ATTN: AMSLC-TP-PB, I. Bartkey 2800 Powder Mill Road Adelphi, MD 20783-1145
2	Commander Armament R&D Center US Army AMCCOM, ARDEC ATTN: SMCAR-TSS SMCAR-TDC Dover, NJ 07801
5	Commander Armament R&D Center US Army AMCCOM, ARDEC ATTN: SMCAR-CCL-FW, H. Khann SMCAR-CCL-CH, A. Cianciosi SMCAR-CCL-CD, W. Gadamski SMCAR-CCJ SMCAR-CCL-A, R. Trifiletti Dover, NJ 07801
1	Commander US Army AMCCOM, ARDEC ATTN: SMCAR-LCS Dover, NJ 07801
2	Director US Army AMCCOM, ARDEC Benet Weapons Laboratory ATTN: SMCAR-LCB-TL SMCWV-QAR, Bldg 44, W. Jarrett Watervliet, NY 12189
2	Commander US Army Armament, Munitions & Chemical Command ATTN: SMCAR-ESP-L, Tech Lib SMCAR-TSE-SW Rock Island, IL 61299
1	Commander US Army Aviation Research and Development Command ATTN: AMSAV-E 4300 Goodfellow Blvd St. Louis, MO 63120
1	Director US Army Air Mobility Research and Development Laboratory Ames Research Center Moffett Field, CA 94035
1	Commander US Army Communications Cmd ATTN: AMSEL-ED Fort Monmouth, NJ 07703

DISTRIBUTION LIST

No. of Copies	Organization
1	Commander ERADCOM Technical Library ATTN: DELSD-L (Reports Section) Fort Monmouth, NJ 07703-5301
1	Director Harry Diamond Laboratories ATTN: DELHD-DE-OS, R. Johnson 2800 Powder Mill Road Adelphi, MD 20783
1	Commander US Army Missile Command RD&E Center ATTN: AMSMI-RD Redstone Arsenal, AL 35898
1	Commander US Army Missile & Space Intelligence Center ATTN: AIAMS-YDL Redstone Arsenal, AL 35898-5500
5	Commander US Army Tank Automotive Cmd ATTN: AMSTA-FVS AMSTA-FVS-G AMSTA-CV-D AMSTA-UL AMSTA-TSL Warren, MI 48397-5000
2	Commander US Army Infantry Center ATTN: AFYC, Col. G. Rodgers Maj. M. Bailey Fort Benning, GA 31905-5000
2	President US Army Infantry Board ATTN: ATZB-IB-SA, Maj. T. Gross L. Tomlinson Fort Benning, GA 31905
4	Commander US Army Infantry School ATTN: ATSH-CD ATSH-CD-CSO-OR ATSH-TSM-FV ATSH-CD-MLS-M Fort Benning, GA 31905
2	Director US Army TRADOC Systems Analysis Activity ATTN: ATAA-SA ATAA-SL, Tech Lib White Sands Missile Range NM 88002
2	Commander US Army Operational Test and Evaluation Agency ATTN: CSTE-TM-IN CSTE-TD 5600 Columbia Pike Falls Church, VA 22041
3	Commander US Army Training & Doctrine Command ATTN: ATCD-SE, ATTE-R ATCD-DCS Ft. Monroe, VA 23651-5000
3	Commander US Army Development and Employment Agency ATTN: MODE-TED-SAB, Maj. C. Ostrand AFZJ-DPT-IM Fort Lewis, WA 98433

DISTRIBUTION LIST

No. of Copies	Organization
1	Commander US Army John F. Kennedy Special Warfare Center & School ATTN: ATSU-CD-ML, S. Putnam Ft. Bragg, NC 28307-5000
1	Naval Sea Systems Command ATTN: SEA-62Y1B Washington, DC 20362
3	Commander Naval Ordnance Systems Cmd ATTN: ORD-9132 Washington, DC 20360
3	Commander US Naval Weapons Center ATTN: Code 233 Code 12 Code 3176 China Lake, CA 93555
1	Commander Naval Special Warfare Group - 2 ATTN: N4, MMCS W. White USNAB, Little Creek Norfolk, VA 23521
3	Commander US Naval Weapons Support Center ATTN: Code 20, C. Zeller G. Dornick J. Massen Crane, IN 47522
2	Commander US Marine Corps ATTN: AX Washington, DC 20380
2	Director Development Center ATTN: MCDEC/D092 MCDEC/D091 Quantico, VA 22134

No. of Copies	Organization
2	Commander USMC Development and Education Command ATTN: RVC-30903, LTC D. Willis CPT S. Walsh Quantico, VA 22134-5040
1	Commander USMC Development Center ATTN: D0310, COL. R. Bowles Quantico, VA 22134
1	Air Force Armament Laboratory ATTN: AFATL/DLODL Eglin AFB, FL 32542-5000
1	AFWL/SUL Kirtland, AFB, NM 87117
10	Central Intelligence Agency Office of Central Reference Dissemination Branch Room GE-47 HQs Washington, DC 20502

Aberdeen Proving Ground

Dir, USAMSAA
ATTN: AMXSY-D
AMXSY-MP, H. Cohen
Cdr, USATECOM
ATTN: AMSTE-TO-F
Cdr, CRDEC, AMCCOM
ATTN: SMCAR-RSP-A
SMCCR-MR
SMCCR-SPS-IL

USER EVALUATION SHEET/CHANGE OF ADDRESS

This Laboratory undertakes a continuing effort to improve the quality of the reports it publishes. Your comments/answers to the items/questions below will aid us in our efforts.

1. BRL Report Number_____ Date of Report_____

2. Date Report Received_____

3. Does this report satisfy a need? (Comment on purpose, related project, or other area of interest for which the report will be used.)_____

4. How specifically, is the report being used? (Information source, design data, procedure, source of ideas, etc.)_____

5. Has the information in this report led to any quantitative savings as far as man-hours or dollars saved, operating costs avoided or efficiencies achieved, etc? If so, please elaborate._____

6. General Comments. What do you think should be changed to improve future reports? (Indicate changes to organization, technical content, format, etc.)

CURRENT ADDRESS

Name

Organization

Address

City, State, Zip

7. If indicating a Change of Address or Address Correction, please provide the New or Correct Address in Block 6 above and the Old or Incorrect address below.

OLD ADDRESS

Name

Organization

Address

City, State, Zip

(Remove this sheet, fold as indicated, staple or tape closed, and mail.)

FOLD HERE

Director
US Army Ballistic Research Laboratory
ATTN: DRXBR-OD-ST
Aberdeen Proving Ground, MD 21005-5066

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO 12062 WASHINGTON, DC
POSTAGE WILL BE PAID BY DEPARTMENT OF THE ARMY

Director
US Army Ballistic Research Laboratory
ATTN: DRXBR-OD-ST
Aberdeen Proving Ground, MD 21005-9989

FOLD HERE

END

DATE

FILMED

DEC.

1987